TECHNICAL CONSIDERATIONS AND COST ESTIMATES FOR TREATING 8,000 TONS CYANIDE-TAINTED PHOTOGRAPHIC FILM CHIPS

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INTRODUCTION

This report has been prepared for Region V USEPA by the Technical Assistance Team as part of a state and federal effort to identify and evaluate potential disposal methods for approximately 8,000 tons of cyanide-contaminated, photographic wastes. This waste is currently being stored in truck trailers in and around Chicago and at a warehouse near Dixon, Illinois. Due to the public health hazard posed by the improper storage of this material, the state and the federal government have been pursuing several alternatives for its immediate treatment and disposal.

To date, a number of potential disposal methods have been identified and are currently under study to determine their feasibility.

This report describes a proposed method for treating the material on site and storing the treated waste film. The report contains technical information with respect to the chemical reactions of the treatment process, description of a method to physically handle the large volume of waste and cost estimates to complete the treatment process.

At the time of report preparation, analytical information supporting assumptions about the treatment process was not available. This information will be included as an addendum to the report upon its receipt. It is anticipated that this information will be provided to US EPA by 3 June 1983.

TECHNICAL CONSIDERATIONS

Based on our evaluation of the material, we feel the treatment method proposed in this report is feasible and can be conducted without threat to human health or the environment.

The chemical reaction to be employed in the treatment process is an oxidation reduction reaction which hydrolizes cyanide with excess chlorine to sodium cyanate (NaCNO). If allowed to react for a longer period of time, oxidation to sodium chloride, sodium carbonate and nitrogen gas. The reaction occurs at standard temperature and pressure and can be accomplished on a large scale with commonly available reagents.

CHEMICAL REACTION

The reaction proceeds as follows:

1. Hydrolysis to CNO-

   a) $2\ CL_2 + 2\ NaCN \quad 2\ CNCl + 2\ NaCl$ (occurs at any pH)

   b) $2\ CNCl + 4\ NaOH \quad 2\ NaCNOH + 2\ NaCl + 2\ H_2O$

The pH should be maintained at 10-12, the materials should be well mixed and the chlorine levels should be monitored to assure required excess chlorine is maintained. Treatment times will depend on how strongly the cyanide is adsorbed or absorbed on the film.

2. Oxidation to N_2

$3\ Cl_2 + 4\ H_2O + 2\ NaCNO^- \rightarrow 3\ Cl_2 + (NH_4)_2\ CO_3 + NaCO_3$ and, finally,

$3\ Cl_2 + 6\ NaOH + (NH_4)_2\ CO_3 \rightarrow 2\ NaHCO_3 + N_2 + 6\ NaCl + 6\ H_2O$

Other compounds potentially present in/on the film (which may include ammonium thiosulfate and sodium silver cyanide can affect these reactions. For example, ammonium thiosulfate will increase the chlorine demand.

To support the technical feasibility of treating the cyanide contaminated film waste by alkaline chlorination a treatability study was devised. In the study, samples taken from a warehouse at the Green River Industrial Complex was subjected to varying concentrations of treatment solution for varying times. Analysis of total and free cyanide in/on the chips before and after treatment will provide data for determining the success of alkaline chlorination as a method of handling the film waste materials.

Treatability Scheme

	2 minutes	3 minutes	60 minutes
Water	1	5	9
2:1, available chlorine cyanide	2	6	10
5:1, available chlorine cyanide	3	7	11
10:1, available chlorine cyanide	4	8	12

The study only provided baseline treatment parameters which might included treatment time and chlorine demand.

References consulted for information presented in this section were:

Wastewater Treatment Technology Volume I, James W. Patterson, Ann Arbor Science Publishers, Ann Arbor, Michigan 1975.

Standard Methods for the Examination of Water and Waste Water, 14th Edition, 1976 American Public Health Association, Washington D.C.

Theories and Practice of Industrial Waste Treatment, Nelson Leonard Numerow, Addison-Wesley Publishing Co. Reading, MA 1963.

MATERIAL HANDLING

The following discussion for a method to handle this large volume of materials is based on the assumption that the material is treatable in its current form. As mentioned earlier in the report bench tests are

currently being conducted to confirm the material is treatable using sodium hypochlorite as the treatment chemical.

In order to accomplish the treatment process, substantial material handling will be required. For purposes of this report, it has been assumed the Chicago area material will be delivered to the Dixon facility at times and in quantities compatible with the process capacity. This will eliminate the need to unload dump trucks from Chicago into storage at Dixon and later remove this material for treatment.

The length of time desired to complete the project has been established at 20 working days. This time schedule requires that approximately 50 tons of waste material be handled per hour. At present, two methods for handling the material during the treatment process have been identified.

1. Chip Rinsing - This option is most attractive due to the lesser degree of material handling required to accomplish treatment. Its feasibility is dependent on how strongly the cyanide is adsorbed to the film.

   The rinsing option requires that the film chips be rinsed with a hypochlorite solution. The chips can either be passed beneath a spray nozzle or placed into a rinse tank containing sodium hypochlorite for 7-10 minutes. After the chips are rinsed, they can be removed from the solution as a nonhazardous waste. The cyanide remaining in the solution will react with the hypochlorite and be neutralized. The rinsate will be collected, analyzed and recycled. The solution will be monitored and replenished as necessary. The treated chips can be conveyed to a dump truck and transported to a warehouse for storage.

2. Chip Soaking - If the cyanide is strongly adsorped or absorbed the rinsing process may not remove all cyanide from the film. In this case, the chips must soak in the sodium hypochlorite solution for up to one hour. This process would be accomplished by charging a mixing tank with a quantity of chips and allowing the chips to react with soodium hypochlorite. After the reaction has proceeded to its desired end point, the treatment solution could be decanted, analyzed, replenished, and discharged to another treatment vessel. The remaining chips could be then loaded into a dump truck for transport to a storage warehouse. This process may take more than 20 working days.

It is desirable to treat these chips in a building to prevent potential blowing of chips. This may not be feasible due to space requirements and the treatment system would have to be erected outdoors. If the treatment process is conducted outside, precautions must be taken to prevent chips from blowing off site.

Decontamination of the current storage facility in Dixon will be required. The decontamination of this facility can occur either in stages as chips are removed from the warehouse, or after the warehouse has been completely emptied. It is recommended that the building be decontaminated in stages to allow replacement of the treated chips to the same warehouse which will eliminate the potential need to lease another building and will minimize hauling/handling of the chips.

Disposal

1. Film Waste

   After treatment the waste will no longer be hazardous and amendable for disposal at either a sanitary landfill or incineration facility. The material may also be burned in an industrial boiler or cement kiln to recover BTU value.

2. Spent Hypochlorite Disposal

   These potential methods for spent solution disposal are currently being investigated:

   a. treatment and discharge to a sewage treatment plant.

   b. treatment and discharge to a surface water.

   c. transport to an industrial waste water treatment facility.

   Cost estimates and feasibility of these options will be determined based on analysis of the treatment solution as the project approaches completion.

COSTS

Recent reconnaissance of the site indicates storage capacity in warehouses at the Green River Industrial Complex adequate to accommodate the material both currently stored there and the additional material to be trucked from Chicago. Contact with the Complex owner indicates he is willing to agree to a one year lease for additional buildings required to store the Chicago material and, if necessary, the material stored on site if this building must be emptied prior to the decontamination examination. Preliminary cost estimates from the owner indicate the monthly lease per building will be approximately $1100. The buildings will require some preparation (boarding up windows and holes) prior to acceptance of the material at a cost of approximately $1400 per building.

The cost to construct and operate the treatment process has been estimated at $11,000 - $12,000 per day. This cost reflects a treatment rate of 50 tons per hour and are based on an eight-hour working day. These costs may be modified under the following conditions:

1. The cyanide must only be reacted to cyanate and not to the final products of the reaction.

2. The volume estimate of material is found to be more or less than that currently being used.

3. The treatment process required is only rinsing chips rather than requiring a residence time in the treatment solution.

4. The contractor works more than an eight-hour day. If contractors work longer days the costs may be reduced as a result of fewer days of treatment and fewer start-ups and shut-downs.

5. On-site transport costs can be minimized through short haul distances to storage buildings.

CONCLUSION

This report has been prepared for US EPA and describes a potential treatment method for waste cyanide-tainted film. Analytical procedures are currently under way to confirm the feasibility of this treatment method.

In addition, some field testing of this process may be required prior to implementation to establish more firm cost estimates for material handling and treatment.

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ADDENDUM #1

Prepared by:

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June 1983

INTRODUCTION

This report has been prepared as an addendum to a report for USEPA 5/24/83 describing technical considerations for the treatment of approximately 16 million pounds of cyanide-tainted photograph film chips. This addendum describes the results of analytical work conducted to characterize the material, a potential treatment facility design and operating procedure, and cost estimates for the fabrication and operation of this system.

ANALYTICAL RESULTS

The following results were obtained from laboratory analysis conducted 26 May - 31 May 1983. The analytical procedure was carried out on the chips to determine their susceptability to treatment and various concentrations and residence times of a sodium hypochlorite solution. The results provide the concentration of cyanide remaining on the chips after treatment. Values are presented in mg/kg. The original chip analysis was 200 ppm cyanide.

TABLE 1

	2 minutes	30 minutes	60 minutes
Water	61	52	33
2:1	59	48	41
5 to 1	62	40	40
10 to 1	51	43	25

The results of this analysis indicate the cyanide is quite mobile and can be easily rinsed from the chips. The analytical laboratory indicated that during the procedure the major portion of the cyanide was removed from the chips within 20 seconds after exposure to a liquid. In addition, the laboratory noted that the chlorine did not begin to be consumed by the cyanide until 45 minutes after the chips had been rinsed with the solution. This indicates that although the cyanide is removed from the chips quite easily by rinsing, the actual neutralization reaction occurs relatively slowly. Subsequently, any treatment system design incorporate the required reaction time into its design to avoid the consumption of the hypochlorite solution.

TREATMENT PROCESS DESIGN

Constraints:

1. 6 million pounds of material in Chicago.
   10 million pounds of material in Amboy.

2. Treatment of all material to be completed within one month of project startup.

3. Decontamination of truck trailers, warehouses and contaminated soil will be required.

Assumptions:

1. Treatment of film will result in the decomposition of cyanide to sodium carbonate, sodium chloride and nitrogen gas.

2. Maximum acceptable concentration of residual cyanide on the film chip is 50 ppm.

3. The rinse solution to be used in the treatment process can be reused.

4. Spent treatment solutions can be discharged to a STP or other at no cost.

The treatment system will consist of 7 teams of 5 people. Each team will be capable of handling 17,500 pounds of chips per hour in the treatment unit. The system consists of a vacuum system to remove the material from trailers or the warehouse and place it into reaction vessels. The reaction vessel is designed to hold 17,500 pounds of chips and approximately 3,000 gallons of a 15% sodium hypochlorite solution. The solution is pumped into the charged reaction vessel containing the chips and allowed to react for approximately 15 minutes. The contents of the vessel are then pumped to a filtration system where the chips are separated from the sodium hypochlorite solution. The solution is then pumped back into a storage tank. The chips are placed in a water rinse tank, removed and then placed in a suitable storage location while the second half of a truck is being emptied and placed in the hypochlorite reaction vessel. The truck can then be decontaminated and the clean chips replaced. The hypochlorite treatment solution will be monitored and replenished to ensure the required 10 to 1 chlorine to cyanide ratio required for treatment. Figure 1 is a schematic diagram of this treatment system.

EQUIPMENT LIST (each treatment system)

2 vacuum systems (dirty chips, clean chips)	$5000
2 4,000-gallon dumpsters capable of holding liquid	$2000
1 trash pump	$1000
filter screen	$2000
1 5,000-gallon hypochlorite solution tank	$7000
5,000 gallons 15% hypochlorite solution	$2000
trailer decon equipment	$1000
pickup truck	$1400
Total cost (per team)	$22,400
Total project equipment cost (per 7 teams)	$166,800

Labor Costs

3 recovery technicians $66/hr per team
operator @ $33/hr
foreman @ $35/hr /hr
project manager

Total crew cost	$400/day per 10/hr.day per team	$1350
Total cost for 7 teams	per 10 hr/day	$9400
Total Labor Project Cost		$196,000

Other Costs

Per diem in town contractor $10/day	$7200
out of town contractor $55/day	($39,600)
Car for Project Manager	$1100
Mileage cost (5,000 mi @ $0.40/mi)	$2000
Safety equip ($1000/team for tyveck overalls, gloves, etc.	$7000
	$17,300

Total Estimated Contingency Cost $475,000

CONCLUSION

The information provided in this addendum to the treatment report previously submitted is based on numerous assumptions about the treatability of the material and equipment and labor costs. Although we feel this system will adequately treat the material at a cost-effective manner, other systems may be devised to treat this substantial volume of material.

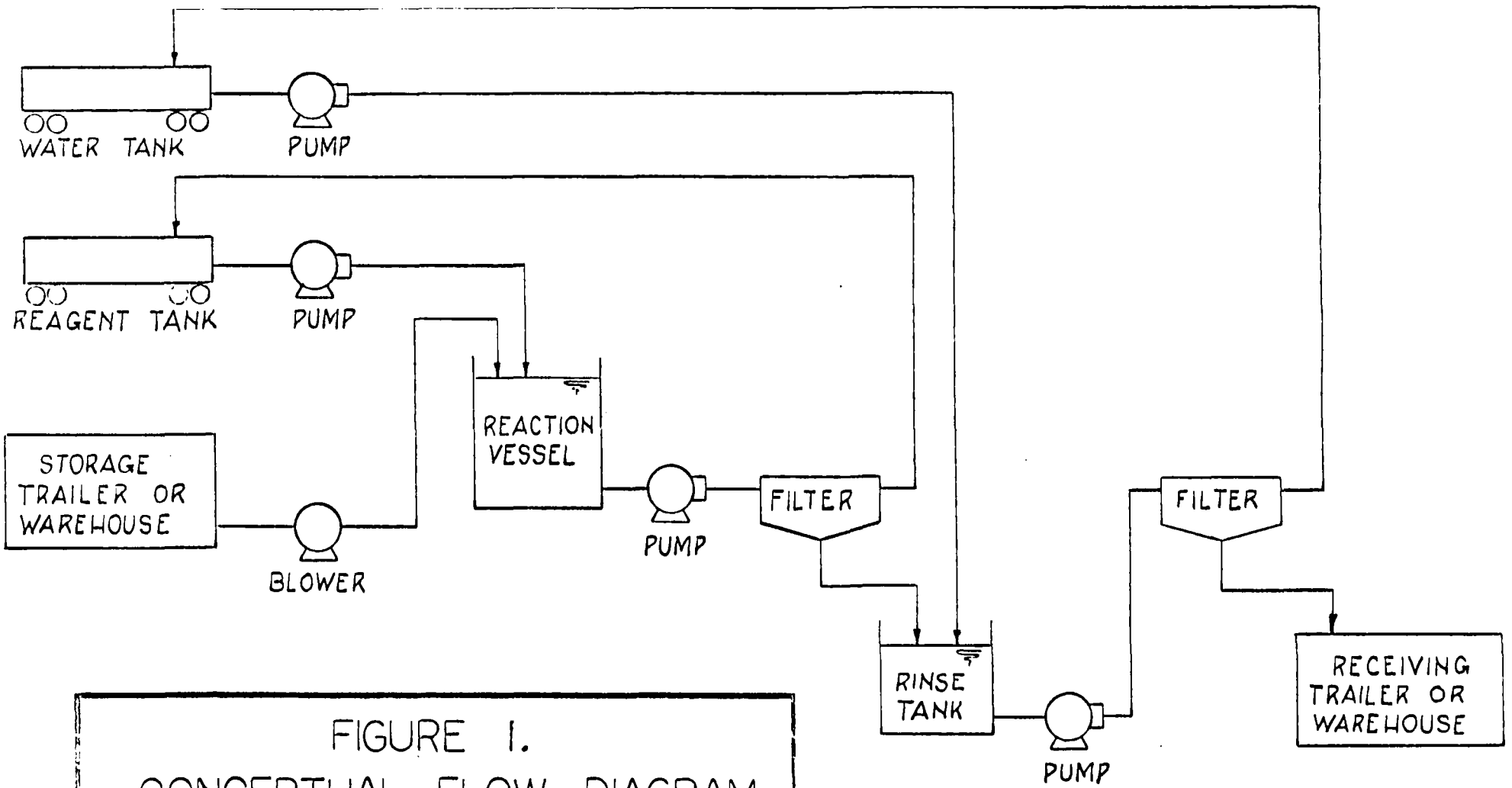

FIGURE 1.
CONCEPTUAL FLOW DIAGRAM
FOR FEASIBLE CYANIDE CHIP
TREATMENT PROCESS

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